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THE HERB STRATA OF THREE CONNECTICUT RIVER OXBOW SWAMP FORESTS

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ABSTRACT

The herb floras of swamp forests in three of four large Connecticut River oxbows in western Massachusetts have been described and compared. The herb stratum at Hatfield includes a lush growth of annual and perennial herbs, lianas, and emergent marsh species, but no seedlings of the dominant canopy tree, *Populus deltoides*. Composition of the herb stratum in Ned's Ditch, Northampton, forest was found to vary markedly during four years of sampling. Seedlings of major canopy species at Ned's Ditch increased steadily through successive years while abundance of floating hydrophytes fluctuated strongly. Ferns and spring-blooming herbs predominated in the herb stratum at Whately which also contained seedlings of all canopy species. Of the herbaceous species sampled, 70% occurred only at one site. An argument is made that floodplain forest, severely limited in New England, should be more stringently protected.

Key Words: Swamp forest, floodplain vegetation, herbaceous flora, wetlands, Connecticut River

INTRODUCTION

Published accounts of floodplain and swamp forest vegetation in New England are chiefly limited to the perceptive comments of Nichols (1915, 1916) on lowlands and stream banks in Connecticut. Floodplain forests elsewhere have been investigated more intensively. However, much of this work has concentrated on overstory

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species with only a few studies examining herbaceous strata in detail (Wistendahl, 1958; Lindsey et al., 1961; Bell, 1974; Keammerer et al., 1975; Barnes, 1978; Hardin and Wistendahl, 1983).

Within an 18 km stretch of the Connecticut River in western Massachusetts, four large oxbow lakes occur. Three are in the active floodplain while the fourth now lies on a higher terrace. We have recently (Holland and Burk, 1982) discussed the relative ages (time since cut-off) of these oxbows. The "youngest" was separated from the main stream in 1840 and remains in large part open water. The others contain varying amounts of open water, marsh, shrub swamp, and forest.

The object of the present study is to describe and compare the floras of the herbaceous strata in the forests of the three older western Massachusetts oxbows. More detailed accounts of the geology, history, and marsh vegetation of these oxbows are found in Robinton and Burk (1971); Burk (1973, 1977), Sackett (1974, unpublished Master's thesis, Smith College, Northampton, Mass.; 1977, unpublished Ph.D. dissertation, U. Mass, Amherst), Burk and Lauermann (1977) and Holland and Burk (1982).

LOCATION AND AGE OF THE STUDY SITES

Figure 1 indicates the location of the study sites. In order of increasing age they are (A) the Hatfield oxbow, which includes two adjacent segments known as Great Pond and Cow Bridge Brook, (B) Ned's Ditch, the northeastern half of a prehistoric oxbow in Northampton, and (C) the Whately oxbow.

The Hatfield oxbow was formed sometime prior to the late 1700's. Depicted as two large ponds on the earliest maps of the area, it was subject to full erosive flow from the Connecticut River during heavy flooding as recently as 1936 (Collins and Schalk, 1937).

Stratigraphy and radiocarbon dating indicate that the prehistoric Northampton oxbow was cut off from the main stem around 710 (±130) yr. B. P. (Holland and Burk, 1982). The Ned's Ditch section is largely forested. Hulbert's Pond, the lower southeastern portion of this oxbow, contains an extensive marsh complex kept open by the Mill River which flows through it into the 1840 oxbow.

The Hatfield and the prehistoric Northampton oxbows tend to be flooded yearly or more often (Brower, 1971). The Whately oxbow is for the most part above the present floodplain. The lower eastern

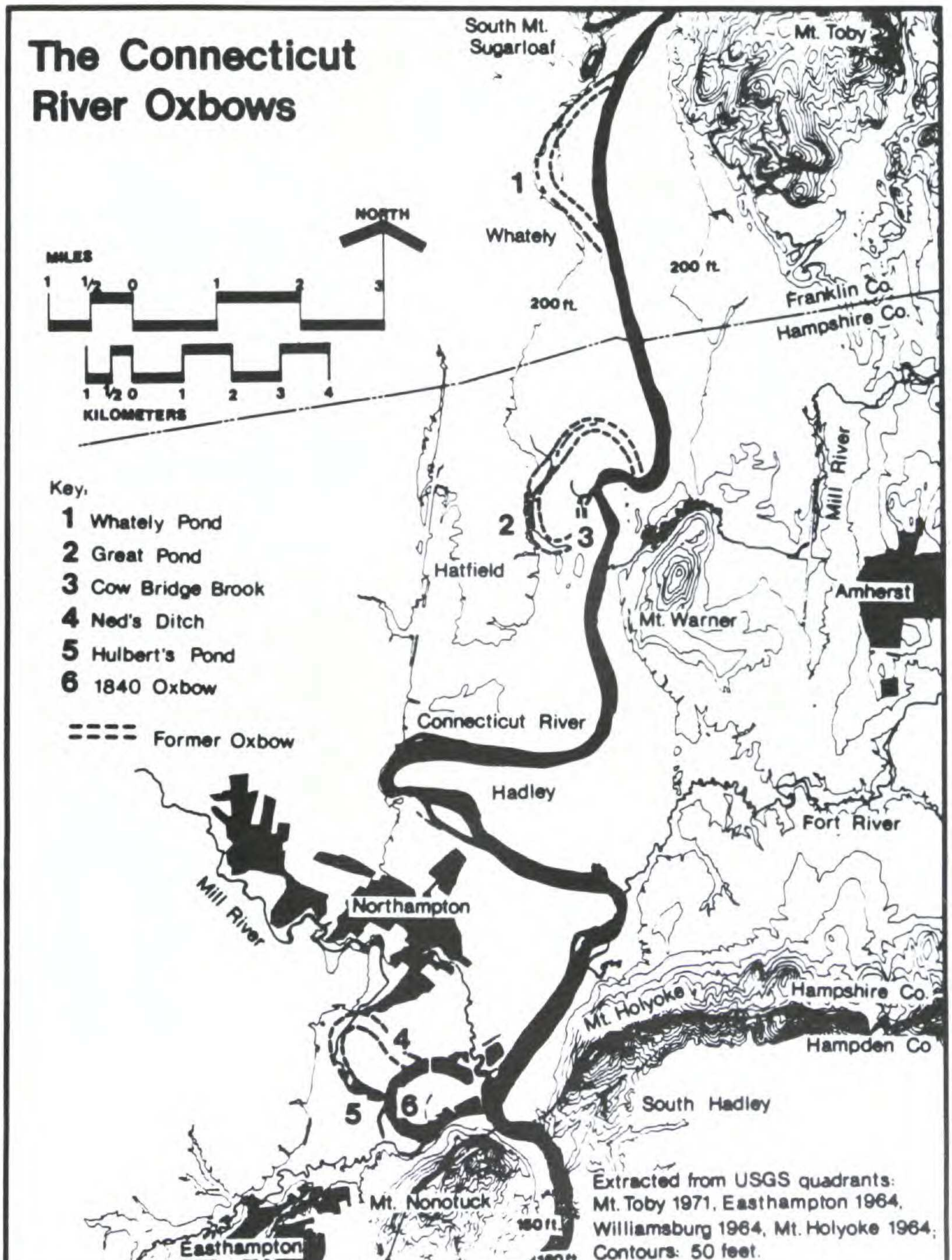

Figure 1. Map of the study area and location of the study sites (from Holland and Burk, 1982. Reprinted with permission from Northeastern Geology, Vol. 4, No.1.)

portions of this oldest site were flooded in 1936, but the western portions have not been flooded at all within historic times (Jahns, 1947).

METHODS

Since each of the oxbows contains a diversity of habitats, sampling techniques were planned to assure that only swamp forest was included. The course of the old river bank can usually be identified. After a general reconnaisance at each site, belt transects approximately 300 m long and 1 m wide were laid out, crossing the former channel at regular intervals.

At Hatfield, 10 belt transects were established at intervals of 575 m. On four of these, swamp forest occurred adjacent to one side of the old river bank in sufficient quantity to lay out a 10 m × 10 m quadrat beginning 3.3 m in from the edge of the forest closest to the bank. Within each 10 m × 10 m quadrat, ten 1 m × 1 m quadrats were laid out, five at regular intervals along the transect and five at regular intervals along a baseline perpendicular to the transect.

Ned's Ditch encompasses approximately half of the total Northampton oxbow. Five transects were laid out at 285 m intervals in Ned's Ditch. Swamp forest occurred adjacent to both sides of the old river bank on all of these. Ten 10 m × 10 m quadrats were established in Ned's Ditch, two on each transect beginning 3.3 m in from the edge of forest at each end of the transect. Within each 10 m × 10 m quadrat, 1 m × 1 m quadrats were laid out as at Hatfield.

Five transects were laid out at 575 m intervals at the Whately site. Sufficient swamp forest was present at Whately to establish five 10 m × 10 m quadrats, one adjacent to the river bank on one transect and two adjacent to the river bank on either end of two other transects. Ten 1 m × 1 m quadrats were laid out within each larger quadrat, as in the other sites.

Presence and coverage as determined by visual estimate were noted for all herbs, vines and woody seedlings under 60 cm height in the 1 m × 1 m quadrats. During 1975, 40 1 m × 1 m quadrats were sampled at Hatfield, 100 at Ned's Ditch, and 50 at Whately. Different numbers of quadrats sampled at each site reflect the different amounts of swamp forest present. The proportion of each oxbow supporting swamp forest was estimated from aerial photographs, USGS topographic maps, and other maps available from local

sources. A comparison of ratios of total area sampled to overall swamp forest present indicated that roughly equal proportions of vegetation were sampled at each oxbow.

Within the study area, few floodplain forest herbs break dormancy before early May, and many begin seasonal development in late May or early June. Therefore sampling was conducted during the last two weeks of July and the first three weeks of August, the period when the herbaceous stratum is most fully developed. Because preliminary observations indicated that the herb stratum of Ned's Ditch varied markedly from year to year, Ned's Ditch was sampled in 1973, 1974, 1975, and 1977. At Hatfield and Whately, belt transects and 10 m × 10 m quadrats were situated during 1974, but sampling at these sites that year was limited to five quadrats along the transect in each 10 m × 10 m quadrat. Full sampling at all sites was conducted in 1975. General collecting was conducted each season to determine species present in the swamp forest at any site but not represented in the quadrats.

For purposes of analysis, a table was prepared listing all species sampled in any quadrat during 1973, 1974, and 1975. In a few instances, specimens could be identified only at the generic level and, in the case of some immature grasses, only to family. These identifications are included in the list but omitted in later floristic comparisons. Species occurring at a study site but not within any quadrat in 1975 are indicated (a) if they appeared in any quadrat at the site during any prior year of sampling or (b) if they were collected elsewhere in swamp forest at the site during 1975. Cover and frequency data are included only for 1975. Species collected at a site but never found within a quadrat are not included.

To document changes in the composition of the flora of Ned's Ditch during the four years of sampling, a table was prepared listing cover values and frequencies for all species encountered each year. This list and maps indicating the locations of the belt transects at each site are available from the authors upon request. Precipitation data used in the discussion of vegetational changes were obtained from Philip T. Ives (personal communication through the study period.)

Unless otherwise indicated in Table 1, nomenclature follows Fernald (1950). Voucher specimens of all species collected have been deposited in SCH.

Table 1. Composition of the herb strata. Percent cover (C) and frequency (F) of species sampled, total number of species present, and total vegetative cover of herbaceous strata of three western Massachusetts oxbow forests in 1975. P indicates sampling prior to 1975 but not that year, X indicates presence in swamp forest elsewhere at the site but not in quadrats. Total cover is the sum of actual cover values for each species.

	Hatfield		Ned's Ditch		Whately	
Species	%C	%F	%C	%F	%C	%F
Herbs and vines						
Agrostis alba L.	4	12.5	2	17	--	--
Amphicarpa bracteata (L.) Fern.	<.5	2.5	<.5	2	--	--
Apios americana Medic.	--	--	1	6	--	--
Aralia nudicaulis L.	--	--	--	--	1	14
Arisaema triphyllum (L.) Schott	<.5	5	<.5	1	<.5	2
Aster divaricatus L.	--	--	--	--	<.5	2
A. vimineus Lam.	--	--	P	P	--	--
Aster spp.	<.5	5	--	--	--	--
Athyrium filix-femina (L.) Roth	1	2.5	X	X	13	30
Bidens tripartita L.	2	47.5	<.5	8	--	--
B. frondosa L.	--	--	1	4	--	--
Boehmeria cylindrica (L.) Sw.[1]	7	85	<.5	9	--	--
Botrychium multifidum (Gmel.) Rupr.	--	--	<.5	1	--	--
Callitriche heterophylla Pursh	<.5	7.5	--	--	--	--
Cardamine pensylvanica Muhl.	--	--	P	P	--	--
Carex tribuloides Wahlenb.	<.5	10	--	--	--	--
Carex spp.	4	22.5	<.5	1	<.5	6
Cicuta maculata L.	<.5	5	--	--	--	--
Circaea quadrisulcata (Maxim.) Franch. & Sav.	1	7.5	--	--	--	--
Clematis virginiana L.	<.5	2.5	--	--	--	--
Clintonia borealis (Ait.) Raf.	--	--	--	--	<.5	2
Commelina communis L.	--	--	P	P	--	--
Convolvulus sepium L.	<.5	2.5	--	--	--	--
Coptis groenlandica (Oeder) Fern.	--	--	--	--	P	P
Cuscuta gronovii Willd.	<.5	15	X	X	--	--
Cyperus strigosus L.	--	--	P	P	--	--
Dennstaedtia punctilobula (Michx.) Moore	--	--	--	--	11	34
Dryopteris spinulosa (O. F. Muell.) Watt	--	--	<.5	5	P	P
D. thelypteris (L.) Gray	1	5	X	X	P	P
Dulichium arundinaceum (L.) Britt.	--	--	7	16	--	--
Echinocystis lobata (Michx.) T. + G.	<.5	2.5	--	--	--	--

[1]May include some immature *Pilea pumila*

Table 1. Continued

Species	Hatfield %C	Hatfield %F	Ned's Ditch %C	Ned's Ditch %F	Whately %C	Whately %F
Eleocharis acicularis (L.) R. & S.	--	--	2	14	--	--
E. obtusa (Willd.) Schultes	P	P	--	--	--	--
Equisetum fluviatile L.	2	22.5	--	--	--	--
Eupatorium rugosum Houtt.	<.5	7.5	--	--	--	--
Galium aparine L.	1	37.5	<.5	8	--	--
Gaultheria procumbens L.	--	--	--	--	2	40
Geum canadense Jacq.	--	--	--	--	P	P
G. virginianum L.	1	15	--	--	--	--
Glechoma hederacea L.	<.5	10	--	--	--	--
Gramineae (unidentified)	7	17.5	<.5	2	--	--
Hypericum virginicum L.	--	--	<.5	1	--	--
Impatiens capensis Meerb.	13	80	--	--	--	--
Leersia oryzoides (L.) Sw.	4	35	P	P	--	--
L. virginica Willd.	--	--	--	--	<.5	6
Lemna minor L.	--	--	34	88	--	--
Ludwigia palustris (L.) Ell.	<.5	30	<.5	16	--	--
L. polycarpa Short & Peter	--	--	<.5	1	--	--
Lycopodium complanatum L.	--	--	--	--	4	28
L. obscurum L.	--	--	--	--	6	30
Lycopus uniflorus Michx.	--	--	<.5	1	--	--
L. virginicus L.	P	P	X	X	--	--
Lysimachia ciliata L.	1	17.5	X	X	--	--
L. nummularia L.	7	10	<.5	3	--	--
L. terrestris (L.) BSP.	--	--	P	P	--	--
Maianthemum canadense Desf.	<.5	2.5	X	X	3	24
Matteuccia struthiopteris (L.) Tod.	5	10	--	--	--	--
Medeola virginiana L.	--	--	--	--	1	14
Mitchella repens L.	--	--	X	X	3	24
Monotropa uniflora L.	--	--	--	--	P	P
Myosotis scorpioides L.	<.5	10	--	--	--	--
Onoclea sensibilis L.	1	7.5	1	3	--	--
Osmunda cinnamomea L.	--	--	--	--	18	46
O. claytoniana L.	--	--	--	--	2	6
O. regalis L.	P	P	3	12.5	<.5	2
Oxalis europaea Jord.	<.5	12.5	--	--	--	--
Parthenocissus quinquefolia (L.) Planch.	1	12.5	X	X	2	18
Peltandra virginica (L.) Schott & Endl.	2	22.5	--	--	--	--
Penthorum sedoides L.	--	--	<.5	1	--	--
Pilea pumila (L.) Gray	X	X	X	X	--	--
Polygonatum pubescens (Willd.) Pursh	--	--	--	--	<.5	2

Table 1. Continued

Species	Hatfield %C	Hatfield %F	Ned's Ditch %C	Ned's Ditch %F	Whately %C	Whately %F
Polygonum sagittatum L.	<.5	7.5	--	--	--	--
P. scandens L.	<.5	2.5	P	P	--	--
Pontederia cordata L.	P	P	--	--	--	--
Potamogeton pectinatus L.	--	--	<.5	1	--	--
Ranunculus abortivus L.	P	P	--	--	--	--
R. flabellaris Raf.	--	--	2	22	--	--
Rhus radicans L.	<.5	2.5	X	X	--	--
Sagittaria latifolia Willd.	P	P	--	--	--	--
Scrophularia lanceolata Pursh	3	7.5	--	--	--	--
Scutellaria lateriflora L.	1	20	<.5	1	--	--
Sium suave Walt.	--	--	<.5	6	--	--
Smilacina racemosa (L.) Desf.	--	--	--	--	P	P
Smilax herbacea L.	--	--	<.5	5	--	--
Solanum dulcamara L.	--	--	<.5	1	--	--
Solidago spp.	<.5	10	--	--	--	--
Spirodela polyrhiza (L.) Schleid.	--	--	3	78	--	--
Streptopus roseus Michx.	--	--	--	--	1	16
Symplocarpus foetidus (L.) Nutt.	3	10	--	--	--	--
Thalictrum polygamum Muhl.	P	P	X	X	--	--
Trientalis borealis Raf.	--	--	--	--	1	36
Trillium undulatum Willd.	--	--	--	--	1	10
Utricularia vulgaris L.	--	--	2	13	--	--
Viola conspersa Reichenb.	1	17.5	--	--	P	P
Vitis spp.[2]	<.5	15	<.5	5	<.5	2
Woody seedlings						
Acer negundo L.	1	22.5	--	--	--	--
A. rubrum L.	P	P	--	--	1	42
A. saccharinum L.	1	37.5	4	35	--	--
Alnus rugosa (DuRoi) Spreng.	1	5	P	P	--	--
Amelanchier laevis Wieg.	--	--	--	--	<.5	2
Betula lutea Michx. f.	--	--	--	--	<.5	6
Betula spp.	--	--	<.5	1	--	--
Cephalanthus occidentalis L.	<.5	2.5	4	31	--	--
Cornus alternifolia L. f.	--	--	--	--	<.5	16
C. amomum Mill.	3	25	--	--	--	--
C. stolonifera Michx.	--	--	2	12	--	--
Fagus grandifolia Ehrh.	--	--	--	--	<.5	2
Fraxinus pennsylvanica Marsh.	--	--	1	4	--	--

[2]Not all specimens of *Vitis* could be identified in quadrats. *V. riparia* Michx. was present at all sites, *V. labrusca* L. at Hatfield and Whately, and *V. aestivalis* Michx. at Ned's Ditch.

Table 1. Continued

Species	Hatfield %C	Hatfield %F	Ned's Ditch %C	Ned's Ditch %F	Whately %C	Whately %F
Hamamelis virginiana L.	--	--	--	--	<.5	16
Ilex laevigata (Pursh) Gray	<.5	2.5	--	--	--	--
I. verticillata (L.) Gray	--	--	1	11	<.5	2
Kalmia latifolia L.	--	--	--	--	4	14
Nyssa sylvatica Marsh.	--	--	--	--	P	P
Populus deltoides Marsh.	--	--	<.5	1	--	--
Prunus serotina Ehrh.	1	5	--	--	2	44
Quercus bicolor Willd.	--	--	<.5	1	--	--
Q. palustris Muenchh.	--	--	<.5	3	--	--
Q. velutina Lam.	--	--	--	--	1	12
Rhododendron viscosum (L.) Torr.	--	--	--	--	1	8
Robinia pseudo-acacia L.	--	--	P	P	--	--
Rubus hispidus L.	P	P	--	--	--	--
Rubus spp.	--	--	--	--	1	14
Salix spp.	--	--	<.5	2	--	--
Sambucus canadensis L.	<.5	2.5	--	--	--	--
Spiraea latifolia (Ait.) Borkh.	<.5	2.5	<.5	1	--	--
Ulmus rubra Muhl.	--	--	<.5	1	--	--
Vaccinium atrococcum (Gray) Heller	--	--	--	--	1	6
Viburnum acerifolium L.	--	--	--	--	<.5	4
V. cassinoides L.	--	--	--	--	1	12
V. recognitum Fern.	--	--	<.5	1	8	36
Total in 1975	55		47		40	
% Cover	79%		71%		89%	

RESULTS AND DISCUSSION

The Hatfield Oxbow

The forest at the Hatfield oxbow shares aspects of floodplain forests described early this century on the lower Connecticut River (Nichols, 1916). These include "rank and luxuriant" undergrowth, a "wealth of lianas", few shrubs, and a trend toward replacement of *Populus deltoides* by shade-tolerant trees.

An estimated 16 ha of swamp forest occupies approximately 10% of the oxbow. *Populus deltoides* dominates an open canopy in association with *Acer saccharinum* and unusually large specimens of *Alnus rugosa*. *Acer negundo*, *Fraxinus pennsylvanica*, *Ulmus rubra*, and *Rhus typhina* occur as small trees. Shrubs are poorly developed with *Alnus rugosa* and *Cornus amomum* most common.

By late summer, the herb stratum supports lush vegetation. Although fewer quadrats were sampled at Hatfield, more herbaceous species were encountered there than at other sites (Table 1). Perennial herbs contribute most to overall cover. However, annuals are also common, with *Impatiens capensis* ranked first in individual coverage. *Boehmeria cylindrica, Lysimachia nummularia,* and *Matteuccia struthiopteris* are important perennial herbs. Vines, including *Amphicarpa bracteata, Clematis virginiana, Convolvulus sepium, Cuscuta gronovii, Echinocystis lobata, Parthenocissus quinquefolia, Polygonum scandens, Rhus radicans, Vitis labrusca* and *V. riparia* form tangled masses on other growth. Typical emergent marsh species of both the Hatfield and Northampton oxbows, including *Equisetum fluviatile, Leersia oryzoides, Ludwigia palustris, Peltandra virginica,* and *Scutellaria lateriflora,* possess high frequency but low cover.

Few species occur as woody seedlings. *Populus deltoides* is not regenerating, but seedlings of *Acer saccharinum, A. negundo,* and *Cornus amomum* are well distributed.

Ned's Ditch

Swamp-forest is more extensive and better developed in Ned's Ditch, covering 30 ha, an estimated 66% of the upper half of the Northampton oxbow. The forest was intermittently logged prior to 1973 but not since. *Acer saccharinum, Quercus palustris,* and *Fraxinus pennsylvanica* are the most important components of the canopy, with *Ulmus rubra, Betula lenta, B. papyrifera, Acer rubrum,* and large specimens of *Cephalanthus occidentalis. Populus deltoides, Salix nigra, S. fragilis,* and *S. rigida* occur as small trees on one site where coarse sand fill was deposited during highway construction. *Cephalanthus occidentalis, Cornus stolonifera,* and *Ilex verticillata* are important shrubs.

Over the first three years of sampling at Ned's Ditch, species richness (total number of species present) and coverage in the herb stratum increased strikingly. The relative contribution of individual species to cover also varied (Table 2). In 1973, coverage was only 14% with 27 species encountered in 100 quadrats. The depauperate vegetation and sparse flora resulted in large part from an atypical early summer flood which followed a very wet spring (Table 3). The herb stratum was completely inundated for at least 10 days in early July (Sackett, 1974 unpublished Master's thesis, Smith College,

Table 2. Yearly variation in Ned's Ditch. Relative cover (percentage of total vegetative cover) represented by species occurring with a total of 5% or more during any sampling period.

Species	Year 1973	1974	1975	1977
Acer saccharinum L.	7	11	6	12
Cephalanthus occidentalis L.	1	8	6	10
Dulichium arundinaceum (L.) Britt.	29	17	10	<.5
Eleocharis acicularis (L.) R. & S.	1	3	3	8
Lemna minor L.	7	3	48	7
Onoclea sensibilis L.	14	11	1	8
Osmunda regalis L.	14	14	4	7
Ranunculus flabellaris Raf.	1	3	3	11

Table 3. Precipitation measurements. Monthly April–August, total April–August, annual 1973–1977, and mean data 1948–1983. Data were recorded in inches at Amherst, MA.

	Month					*Total*	
Year	April	May	June	July	August	April–August	Year
1973	6.40	5.45	4.48	3.33	2.24	21.90	46.65
1974	3.81	4.01	3.46	3.65	3.97	18.90	44.71
1975	2.87	2.10	4.68	10.56	6.13	26.34	59.97
1976	3.40	4.49	2.97	1.58	6.06	18.50	39.63
1977	4.91	3.57	3.83	4.04	5.94	22.29	55.79
Mean Data from 1948–1983							
	4.00	3.57	3.88	3.55	3.86	18.86	44.06

Northampton, Mass.). By August, *Dulichium arundinaceum*, *Onoclea sensibilis*, and *Osmunda regalis* together accounted for 8% coverage. *Lemna minor* and *Spirodela polyrhiza* contributed little cover but occurred at high frequencies.

Relatively dry conditions during the frost-free period of 1974 allowed successful establishment or re-establishment of numerous species. Cover increased to 36% with 36 species present. *Dulichium arundinaceum*, *Onoclea sensibilis*, and *Osmunda regalis* were again the most prominent herbs, contributing, with *Dryopteris spinulosa*, 19% coverage. *Lemna minor* and *Spirodela polyrhiza* continued with low cover but high frequency.

The 1975 season was unusually wet and, following heavy rainfall in July (Table 3), shallow standing water was present in most of the quadrats through the sampling period. Cover reached 71% with 47 species encountered. One invader, *Ludwigia polycarpa*, is included in the Massachusetts list of rare and endangered species (Crow et al., 1981). *Lemna minor*, intermixed with *Spirodela polyrhiza*, was most important, contributing 34% cover. Other frequent "errant hydrophytes" (Mueller-Dombois and Ellenberg, 1974) were *Ranunculus flabellaris* and *Utricularia vulgaris*. *Dulichium arundinaceum* increased while ferns as a group declined.

Some woody seedlings present before the August, 1973 sampling may have been destroyed by the July flood. Woody seedlings increased from 5 to 13 species from 1973 to 1975, with coverage by woody seedlings increasing from less than 2% to over 12%. All canopy trees were represented in the herb stratum in 1975.

During 1977, another wet season with precipitation more evenly distributed than in 1975, coverage was 73%, slightly higher than in 1975 with 41 species present. Woody species contributed more than 23% cover (Table 2). *Ranunculus flabellaris* and *Eleocharis acicularis* increased and *Dulichium arundinaceum* declined to very low levels. *Lemna minor* decreased but was still very frequent, as was *Spirodela polyrhiza*. Seedlings of *Fraxinus pennsylvanica* occurred in 51% of the quadrats.

During the four years of sampling at Ned's Ditch, 61 taxa were identified at the specific level within quadrats. Of these, 16 occurred every year. In addition to the species listed in Table 2, these included *Agrostis alba*, *Apios americana*, *Dryopteris spinulosa*, *Ilex verticillata*, *Pilea fontana*, *Quercus palustris*, *Spirodela polyrhiza*, and *Vitis riparia*. Their life forms include six herbaceous perennials, four woody seedlings, two "errant hydrophytes", one annual, and two vines. In addition, immature specimens of *Bidens* spp., probably mostly *B. cernua* and *B. tripartita* were sampled every year. Ferns as a group contributed about 5% of the total coverage during 1973 and 1975 and more than twice that amount in 1974 and 1977. The canopy species, well represented by seedlings, are apparently replacing themselves, and, as long as flooding continues, the forest might be expected to continue in a persistent state of "hydric disclimax" (Daubenmire, 1968) or "pulse stability" (Odum, 1969).

The Whately Oxbow

The lower eastern portions of the Whately oxbow support a poorly drained complex of forest, marsh, and open water. The upper western portions are almost entirely forested; much of this woodland occurs on slopes leading up to a higher river terrace. Only about 25% of the Whately oxbow, an estimated 18 ha, supports swamp forest suitable for sampling.

The forest has been occasionally logged but apparently never clearcut. *Acer rubrum* and *Prunus serotina* are the most important trees in association with *Quercus alba* and *Nyssa sylvatica*. *Amelanchier laevis*, *Castanea dentata*, and *Tsuga canadensis* are present as small trees; some specimens of *Hamamelis virginiana* are also large enough to transgress the canopy. *Viburnum dentatum* and saplings of all overstory species form a dense shrub stratum.

The herb stratum is very well developed with a total coverage of 89%. Perennials and woody seedlings are the most important life forms. Vines are scarce while annuals and "errant hydrophytes" are lacking. Ferns are more abundant at Whately than at any other site, with *Osmunda cinnamomea*, *Athyrium filix-femina* and *Dennstaedtia punctilobula* predominant. These, with *Lycopodium complanatum* and *L. obscurum*, contribute 52% cover. Spring-blooming perennial herbs, generally absent at other sites, are abundant. These include *Aralia nudicaulis*, *Clintonia borealis*, *Coptis groenlandica*, *Medeola virginiana*, *Polygonatum pubescens*, *Smilacina racemosa*, *Streptopus roseus*, *Trientalis borealis*, and *Trillium undulatum*. *Epigaea repens* is also present as is *Monotropa uniflora*. *Maianthemum canadense* occurs at all three sites and *Mitchella repens* at Ned's Ditch and Whately.

Woody seedlings account for more than 20% of the cover with all canopy species represented. *Acer rubrum* and *Prunus serotina* occur with highest frequencies; although the prevalence of these species may reflect disturbance, there is no reason to believe the general composition of the overstory will change under present conditions.

FLORISTIC TRENDS AND COMPARISONS

Overstory strata of floodplain forests are generally characterized by few wide-ranging species with similar life histories (White, 1979). Herb strata of these forests differ markedly, however. In our study,

excluding taxa identified only above the species level, 94 species of herbs and vines were sampled. Of these, 70% were found at a single site, with seven species occurring in all three oxbow forests. Most of the 27 species shared by two sites occurred jointly in Hatfield and Ned's Ditch. Similarly, of the 32 species represented by woody seedlings in the oxbow forests, 75% were limited to one site and none occurred at all three sites. Hatfield and Ned's Ditch shared half the woody species occurring at two sites; one of these, *Acer saccharinum*, was a potential overstory tree. More species of woody seedlings were found at Whately than elsewhere and 75% of these occurred only there.

Comparable data from other river systems are few; some of the most interesting come from Wistendahl's (1958) study of the floodplain of the Raritan River in New Jersey. On one stretch of the Raritan, three forest types can be distinguished running more or less parallel to one another along one side of the channel (Buell and Wistendahl, 1955; Wistendahl, 1958). These are (1) outer floodplain forest characterized by a diverse overstory including *Fagus grandifolia, Acer saccharum, Liriodendron tulipifera, Ulmus rubra,* and *Tilia americana,* (2) inner floodplain forest with *Acer rubrum, Ulmus americana,* and other wetland trees, and (3) a forest on a high terrace characterized by *Acer saccharum* in association with tree species more frequent on drier sites.

Wistendahl's methods were generally similar to ours except that he sampled twice during the summer. Excluding taxa identified only to genus level, 56 species of herbs and vines were recorded in the three Raritan forests. Of these, 50% occurred at a single site, while 11 species occurred in all three forests. As in the western Massachusetts oxbows, the greatest number of species shared by two sites occurred in the more frequently flooded sites, and the higher (terrace) site had more species represented as woody seedlings. Herbs and vines were poorly represented in the Raritan terrace, and most of those sampled (83%) were also present in one or both of the other sites. Of the 14 species represented by woody seedlings in the Raritan forests, 57% were limited to one site and 29% occurred at all sites. Possible explanation for the greater similarity of the herb strata within the three Raritan forests is that the sites lie immediately adjacent to one another and that the geological processes which formed them are more gradual than the cut-off of

an oxbow, which often takes place in the course of a single major flood event.

A comparison of the various floras of the Massachusetts and New Jersey forests shows that of the 56 species of herbs and vines sampled on the Raritan, 16 were recorded in at least one western Massachusetts site: 12 at Hatfield, 8 at Ned's Ditch, and 4 at Whately. In both cover and shared species, the inner floodplain forest on the Raritan most closely resembles the Hatfield site, while the outer floodplain and terrace forests show little resemblance to any western Massachusetts site.

The herbaceous floras of the western Massachusetts oxbows bear less floristic resemblance to those of bottomland forests along the Missouri River in North Dakota (Keammerer et al., 1975). The North Dakota forests occur near the western limit of "northern floodplain forest" (Vankat, 1979) and have not been flooded since 1954 because of dam and reservoir construction. Of the 216 species, both woody and herbaceous, found in the North Dakota forests, only 20 are represented in the forests of the western Massachusetts oxbows. No species restricted to cottonwood (*Populus deltoides*) forest in North Dakota occurs in the western Massachusetts sites. Twenty species found in North Dakota bottomland forests generally, or restricted to more mesic sites, also occur in one or more western Massachusetts oxbow forests: 15 at Hatfield, 12 at Ned's Ditch, and 1 at Whately.

Only four herbaceous species occur jointly in the Raritan, North Dakota, and western Massachusetts sites: *Amphicarpa bracteata*, *Circaea quadrisulcata*, *Ranunculus abortivus*, and *Scutellaria lateriflora*. All four of these occur at Hatfield, two occur in Northampton, and none at Whately.

Ferns are important at all the western Massachusetts sites and several fern species are also included by Nichols (1915, 1916) as characteristic of floodplains and swamp forests in Connecticut. Ferns are scantily represented at sites described elsewhere within the northern floodplain forest from New Jersey (Wistendahl, 1958) through Ohio (Hardin and Wistendahl, 1983), Indiana (Lindsey et al., 1961), Illinois (Bell, 1974), and Wisconsin (Barnes, 1978) west into North Dakota (Keammerer et al., 1975).

An increasing abundance of non-native species in cultivated fields near the three western Massachusetts oxbows was recognized

by the mid-Nineteenth Century (Judd, 1863). Non-natives are now of considerable importance in various stages of old field succession there (Walker, 1980, unpublished Master's thesis, Smith College, Northampton, Mass.). The land surrounding the oxbows has been heavily cultivated since the Colonial period or earlier, but non-natives are scarce in the oxbow forests. At the Hatfield oxbow, *Lysimachia nummularia* contributes 7% cover and *Glechoma hederacea*, *Myosotis scorpioides*, and *Oxalis europaea* occur at low abundance. *Commelina communis*, *Lysimachia nummularia*, and *Solanum dulcamara* are present though not abundant at Ned's Ditch. No non-natives at all were sampled at Whately.

Non-native species are also relatively unimportant in the herb strata of the floodplain and terrace sites along the Raritan (Wistendahl, 1958). Although these areas are surrounded by agricultural land, only five of the 56 herbs reported are introduced and only two, *Lysimachia nummularia* on the inner floodplain and *Alliaria officinalis* on the outer floodplain, contribute coverage greater than 1%.

In contrast, Keammerer et al. (1975) found that 18.6% of the flora of the Missouri River bottomland forests in North Dakota were non-natives, primarily of European or Eurasian origin. Some of these occurred only on disturbed sites or were persistent after cultivation; others were common or abundant. Johnson et al. (1982) reported recent changes in the composition of the North Dakota forests, including poor reproduction of major overstory species, resulting from altered stream flow and flooding regime. The higher representation of non-natives in the flora may also reflect disruptions of this sort.

CONSERVATION

Floodplain habitats along major streams in New England are severely restricted. They are also increasingly threatened by urban development and by plans to reduce or eliminate flooding (Brower, 1971; Franz and Bazzaz, 1977; Sackett and Nagazina, 1978). The entire Northampton oxbow, which includes Ned's Ditch, is owned by the Massachusetts Audubon Society and is largely preserved. Both the Hatfield and Whately oxbows, however, suffer multiple private ownerships which might allow unrestricted logging at any time. In addition, proposed alterations of flow on the Connecticut

River may result in trends on the floodplain similar to those reported by Johnson et al. (1982), whether logging is restrained or not. The Massachusetts oxbows are of particular interest because they support vegetation which has developed on sites available for colonization during differing lengths of time within a single river system. They support floristic assemblages substantially different from those described elsewhere and therefore deserve more rigorous legal protection than that afforded them at present.

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